6. Тадқиқот натижаларига кўра, суғурталовчиларнинг юқори капиталлашув даражасига эришишида, уларнинг суғурта қилдирувчилар олдидаги мажбуриятларини бажара олиш қобилиятининг ошишида, миллий суғурта компаниялари акцияларининг бир қисмини хорижий нуфузли суғурта компанияларига сотиш орқали ҳамкорликда қўшма суғурта компанияларини ташкил қилиш таклиф этилади ва натижада суғурта компаниялари томонидан халқаро рейтинг агентликларининг рейтингларини олишларида муҳим омил бўлиб хизмат қилади.

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МАРКОВИЦ МОДЕЛИ БЎЙИЧА ИНВЕСТИЦИОН ПОРТФЕЛИНИ ШАКЛЛАНТИРИШ (КОРХОНАЛАР МИСОЛИДА)

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Аннотация. *Мақолада Г.Марковицнинг инвестицион портфель моделини шакллантириш босқичлари кўриб чиқилган. Амалий Excel дастурий таъминоти орқали портфелнинг берилган даромадлилик даражасида рискини минималлаштириш бўйича таҳлил амалга оширилган. Шунингдек ушбу моделнинг афзаллик ва камчиликлари кўрсатиб ўтилган.*

Калит сўзлар: *инвестицион портфель модели, даромадлилик, риск, ўрта қиймат, стандарт четланиш, акция, ковариацион матрица.*

ФОРМИРОВАНИЕ ИНВЕСТИЦИОННОГО ПОРТФЕЛЯ ПО МОДЕЛИ МАРКОВИЦА (НА ПРИМЕРЕ ПРЕДПРИЯТИЙ)

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Аннотация. *В статье рассматривается этапы формирование модели инвестиционного портфеля Г.Марковица. С помощью программного обеспечения Excel проанализирован минимизация уровня риска портфеля при заданном уровне доходности. Также приводятся преимущества и недостатки моделя.*

Ключевые слова: *модель инвестиционного портфеля, доходность, риск, среднее значение, стандартное отклонение, акция, ковариационнная матрица.*

FORMATION OF AN INVESTMENT PORTFOLIO ACCORDING TO THE MARKOWITZ MODEL (ON THE EXAMPLE OF ENTERPRISES)

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Abstract. *In the article the stages of the formation of H. Markowitz's investment portfolio model are discussed. Using Excel software, the minimization of the risk level of the portfolio at a given level of profitability is analysed. The advantages and disadvantages of the model are also given.*

Keywords: *investment portfolio model, profitability, risk, average value, standard deviation, stock, covariance matrix*

Introduction. Although economists have formed many views on risk, risk assessment has been viewed as a standard financial statement analysis. American economist Harry Markowitz (Markowitz, Portfolio Selection, 1952) was the first to develop a mathematical model of investment portfolio formation in 1952. He explained it with a mathematical approach to portfolio risk, diversification, and asset selection.

Markowitz's investment portfolio model is based on two quantitative variables for any financial instrument, namely risk and return. In this case, the yield of the instrument is a set of mathematical expectations (average value) of income. Risk, on the other hand, is defined as the spread of this yield around mathematical expectations and is represented by a standard deviation.

This theory also laid the foundation for the idea of building an optimal portfolio by selecting assets located within the "efficient frontier" (Markowitz, Foundations of portfolio theory, 1991). Accordingly, the efficient frontier is found by determining the share of assets by minimizing the risk, taking into account the condition that the expected return on the portfolio is constant. As a result, such a portfolio provides the best return with minimal risk.

Reference analysis. Contrary to popular belief, risk assessment and diversification were studied before Markovitz's portfolio theory. Rubinstein (M.Rubinstein, 2002) noted that when the Russian economist Bernoulli (Bernoulli, 1954) proved in 1938 that risky decisions could be assessed on the basis of expected profitability, he focused on risk reduction without reducing profitability through diversification.

Before Markovitz, in 1906, Irving Fisher (Fisher, 1906) estimated economic risk using variance. Tobin (Tobin, 1958) linked investment portfolio risks to profitability variance.

Benjamin Graham (Graham, 2006), who is considered the father of modern securities analysis, proposed his idea of a safety margin in risk assessment as well as diversification practices to reduce risk. Although well-known proponents of this value-based investment methodology include Jeremy Grantham and Warren Buffett (Hagstrom, 2013), these scientific views have not been further explored by the Society of Financial Mathematicians.

Although economists have formed many views on risk, risk assessment has been viewed as a standard financial statement analysis. Markowitz first described portfolio risk, diversification, and a mathematical approach to asset selection. This mathematical apparatus consisted of the expected (average) value, variance, and covariance of an asset. Markowitz's portfolio theory was a critical innovation in risk assessment, for which the author was awarded the Nobel Prize.

The assessment of portfolio risk based on Markovitz's portfolio theory was studied by another American economist, William Sharp (Sharpe, 1966), and he became known as the Sharp coefficient.

The Sharp ratio can be interpreted as an additional return on the risk-free interest rate for each risk identified using Markovitz portfolio theory. The Sharp ratio calculates portfolio risk from the point of view of determining the quality of portfolio return that corresponds to a given level of risk. It can be seen that the Sharp coefficient is similar to the t-statistic.

Another variant of the Sharp coefficient is the Sortino (Price, 1994) coefficient, in contrast to which the standard deviation of the portfolio in the denominator is set to a value lower than the expected return on the portfolio (μ_p). This coefficient has the same value as Sharp, except that it does not take into account the change in portfolio profitability for the case higher than μ_p, i.e., in this case the portfolio profitability will have to be reduced.

Simultaneously with Markovitz, his portfolio theory was studied by another American economist. Markovitz states: "Based on Markovitz's (1952) study, I am often referred to as the father of modern portfolio theory (ZPN), but Roy (Roy, 1952) is

equally entitled to claim such recognition." (Rubinstein, 2012)

Research methods. An important aspect of risk and risk assessment is portfolio diversification. Diversification is the reduction of overall risks by investing in multiple assets as well as maintaining potential returns. Because risks do not affect all assets equally. At the same time, of course, there are risks in the economy that cannot be mitigated through diversification (e.g., interest rate risk).

1.1. Markowitz investment portfolio profitability calculation.

The total return of a portfolio is calculated as the weighted sum of the returns of each financial instrument (asset) within it. This is expressed by the following equation (Яновская, 2016):

$$r_p = \sum_{i=1}^{n} w_i \times r_i \qquad (1)$$

Here:

r_p is the profitability investment portfolio;

w_i is the share of the i-th financial instrument in the portfolio;

r_i is the profitability of the i-th financial instrument.

1.2. Markowitz investment portfolio risk assessment.

In the Markowitz model, a separate financial instrument is evaluated with a standard deviation of profitability to determine the risk. In calculating the risk on the portfolio, it is necessary to assess the risk, reflecting the total changes in each of its assets, as well as their interdependence and impact (through covariance). To do this, we use the following formula (Яновская, 2016):

$$\sigma_p = \sqrt{w_i \times w_j \times v_{ij}} = \sqrt{\sum_{i=1}^{n} w_i^2 \times \sigma_i^2 + 2\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} w_i \times w_j \times k_{ij} \times \sigma_i \times \sigma_j} \qquad (2)$$

Here:

σ_p is the investment portfolio risk;

σ_i is the standard deviation of the yield of the i-th financial instrument;

k_{ij} is the correlation coefficient between the i-th and j-th financial instruments;

w_i is the share of the i-th financial instrument in the portfolio;

v_{ij} is the covariance of the yield of the i-th and j-th financial instruments;

n is the number of financial instruments in the investment portfolio.

To form an investment portfolio, it is necessary to address the issue of optimization. The problem of optimization is to minimize the risk ($\boldsymbol{r_p}$) at the level of profitability of a given portfolio.

The following table presents the formula for determining the optimal share of financial instruments and the constraints placed on it.

Table 1.

Portfolio Optimization Formula and Limitations

Minimal risk portfolio	$\begin{cases} \sqrt{\sum_{i=1}^{n} w_i^2 \times \sigma_i^2 + 2\sum_{i=1}^{n-1}\sum_{j=i+1}^{n} w_i \times w_j \times k_{ij} \times \sigma_i \times \sigma_j} \to min \\ \sum_{i=1}^{n} w_i \times \sigma_i > r_p \\ \sum_{i=1}^{n} w_i = 1 \\ w_i \geq 0 \end{cases}$ (3)

In addition, according to the model, the sum of the share of financial instruments in the portfolio should be equal to 1.

Findings. Let's look at a practical example using Excel to build an investment portfolio based on the Markowitz model. To do this, we use open data on the shares of companies of the republic, including: JSC "Tashkentvino Kombinati" (TKVK), JSC "Kyzylkum Tsement" (KZSM), JSCB "UzSanoat QurilishBank" (SQBN) and JSC "Kapital Sug'urta" (KASU) (Republican stock exchange «TOSHKENT», 2021).

We perform a portfolio analysis consisting of the shares of the above-mentioned companies. The joint-stock companies under study belong to the industrial and financial sectors of the economy. Such selection increases portfolio diversification and reduces market risk.

According to the model requirement, data on stock price dynamics are obtained from daily statistics for a period of at least one month. Taking such a period interval in forecasting allows a more accurate calculation of the profitability and risk of the portfolio. Table 2 below shows the daily quotation (price) of shares of the studied companies for the period from 03.02.2021 to 02.03.2021.

Table 2.

Data on the daily quotation of shares of companies of the Republic of Uzbekistan [1]

№	Date	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank	Kapital Sug'urta
1	03.02.2021	200000	1550,01	17,48	2,76
2	04.02.2021	245000	1599	16,8	2,76
3	05.02.2021	245000	1600	17,09	2,76
4	06.02.2021	245000	1575	16,5	2,76
5	07.02.2021	245000	1600	17,1	2,76
6	10.02.2021	225000	1551	16,5	2,76
7	11.02.2021	225000	1570	16	2,76
8	12.02.2021	210000	1552,02	16,99	2,76
9	13.02.2021	215000	1560	17	2,76
10	14.02.2020	220000	1560	16	2,87
11	17.02.2020	230000	1557	15	2,5
12	18.02.2020	250000	1590	15	2,8
13	19.02.2020	250000	1570	15	2,8
14	20.02.2020	250000	1600	15,49	2,8
15	21.02.2020	250000	1575	15,49	2,8
16	24.02.2020	250000	1575,01	15	2,8
17	25.02.2020	250000	1580	15	2,87
18	26.02.2020	215000	1600	15,5	2,3
19	27.02.2020	215000	1605	16,39	1,84
20	28.02.2020	240000	1605	16,2	1,9

In the next stage of portfolio formation, it is necessary to calculate its daily return on each share. (Жданов, 2021).

To do this, we use the formula of percentages in Excel, that is, we perform the following operations:

Profitability of "Tashkentvino Kombinati" = LN (B3/B2)
Profitability of "KyzylkumTsement" = LN (C3 / C2)
Profitability of "UzSanoatQurilishBank" = LN (D3 / D2)
Profitability of "Kapital Sug'urta" = LN (E3 / E2)

Here, the values in cells B3 and B2 are the next date price and the previous date price, respectively. In determining profitability, Excel calculates how much the price for each subsequent day has changed relative to the previous day. Excel automatically calculates the entered data and the result is shown in Table 3 below.

Table 3.

Results of the calculation of the daily return of the stocks in Excel for the Markowitz model [2]

№	Date	Tashkentvino Kombinati	Kyzylkum Tsement	UzSanoatQurilishBank	Kapital Sug'urta
1	03.02.2020				
2	04.02.2020	20,29408%	3,11171%	-3,96785%	0,00000%
3	05.02.2020	0,00000%	0,06252%	1,71146%	0,00000%
4	06.02.2020	0,00000%	-1,57484%	-3,51331%	0,00000%
5	07.02.2020	0,00000%	1,57484%	3,57181%	0,00000%
6	10.02.2020	-8,51578%	-3,11037%	-3,57181%	0,00000%
7	11.02.2020	0,00000%	1,21757%	-3,07717%	0,00000%
8	12.02.2020	-6,89929%	-1,15183%	6,00362%	0,00000%
9	13.02.2020	2,35305%	0,51285%	0,05884%	0,00000%
10	14.02.2020	2,29895%	0,00000%	-6,06246%	3,90814%
11	17.02.2020	4,44518%	-0,19249%	-6,45385%	-13,80213%
12	18.02.2020	8,33816%	2,09731%	0,00000%	11,33287%
13	19.02.2020	0,00000%	-1,26584%	0,00000%	0,00000%
14	20.02.2020	0,00000%	1,89280%	3,21445%	0,00000%
15	21.02.2020	0,00000%	-1,57484%	0,00000%	0,00000%
16	24.02.2020	0,00000%	0,00063%	-3,21445%	0,00000%
17	25.02.2020	0,00000%	0,31632%	0,00000%	2,46926%
18	26.02.2020	-15,08229%	1,25788%	3,27898%	-22,14029%
19	27.02.2020	0,00000%	0,31201%	5,58314%	-22,31436%
20	28.02.2020	11,00009%	0,00000%	10,47502%	3,20883%

In the next step, we determine the mathematical expectation of the return determined for each stock (Жданов, 2021). To do this, we calculate the arithmetic mean for the entire period (Table 4). The expected return for each stock is determined using the special AVERAGE formula function in Excel in the following sequence:

Expected profitability of "Tashkentvino Kombinati" = AVERAGE (F2: F21)
Expected profitability of "KyzylkumTsement" = AVERAGE (G2: G21)
Expected profitability of "UzSanoatQurilishBank" = AVERAGE (H2: H21)
Expected profitability of "Kapital Sug'urta" = AVERAGE (I2: I21)

Here, the values in cells F2 and F21 are the yield levels for the months, respectively. So, as a result of performing the above steps in Excel, the expected return (average value) of each share of the companies under study is calculated (Table 3).

Table 4.

Data on the daily quotation of shares of companies of the Republic of Uzbekistan [3]

№	Date	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank	Kapital Sug'urta
1	03.02.2020				
2	04.02.2020	20,29408%	3,11171%	-3,96785%	0,00000%
...	...	...	...	...	...
19	27.02.2020	0,00000%	0,31201%	5,58314%	-22,31436%
20	28.02.2020	11,00009%	0,00000%	10,47502%	3,20883%
Expected profitability (ri)		0,95959%	0,18349%	0,21244%	-1,96514%

According to the results obtained after performing two operations using Excel, the monthly return on the shares of JSC "Kapital Sug'urta" for a period of one year turned out to have a negative expected return (the last column of Table 4). According to the Markowitz investment portfolio model, the shares of this company are required to be excluded from the portfolio.

In the next step, we assess the variability (volatility) relative to the mathematically expected return of each stock. (Жданов, 2021). To assess the risk of each stock, it is necessary to calculate its variability (volatility) relative to the mathematically expected return. To do this, the next step in the model is to calculate the standard deviation of the expected return on each studied stock using the STDEV formula function of Excel in the following sequence:

Tashkentvino Kombinati risk = STDEV (F2: F21)
KyzylkumTsement risk = STDEV (G2: G21)
UzSanoatQurilishBank risk = STDEV (H2: H21)

Here, the values in cells F2 and F21 are the yield levels for the months, respectively. To assess the risk of a stock, its standard deviation is as follows by following the steps in Excel. We have the information in Table 5.

Table 5.

Data on the daily quotation of shares of companies of the Republic of Uzbekistan [4]

№	Date	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank
1	03.02.2020			
2	04.02.2020	20,29408%	3,11171%	-3,96785%
...	...	...	...	...
19	27.02.2020	0,00000%	0,31201%	5,58314%
20	28.02.2020	11,00009%	0,00000%	10,47502%
Expected profitability (ri)		0,95959%	0,18349%	0,21244%
Equity risk (σ)		7,31459%	1,50249%	4,42160%

In the next step, we assess the risk of the entire investment portfolio (Жданов, 2021). We have the primary data needed to calculate the share of the stock in the investment portfolio. To assess the risk of the entire investment portfolio, we use the "Add-on" function in Excel. To do this, go to the Main menu → "Data" → "Analysis of data" → "Covariance". Using the window that appears, we can determine the covariance between stock returns. To do this, select the checkbox in the window "Input interval" with the monthly yield of all shares, and in the "Grouping" option select the function "on the table" and click "OK" to get the desired result. We will link the results to a separate cell at the bottom of our table using the Exit Interval option.

Table 6.

Calculation of the covariance matrix for Markovitz's investment portfolio in Excel [5]

№	Date	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank	Tashkentvino Kombinati	Kyzylkum Tsement	UzSanoat QurilishBank
1	03.02	200000	1550,01	17,48			
2	04.02	245000	1599	16,8	20,294%	3,111%	-3,967%
...	...	...	...	...	...	...	...
19	27.02	215000	1605	16,39	0,000%	0,312%	5,583%
20	28.02	240000	1605	18,2	11,000%	0,000%	10,475%
Expected profitability (ri)					0,959%	0,183%	0,212%
Equity risk (σ)					7,314%	1,502%	4,421%
Covariance matrix of stock interdependence							
26	Tashkentvino Kombinati				0,0050	0,0004	-0,0003
27	KyzylkumTsement				0,0004	0,0002	0,0000
28	UzSanoatQurilishBank				-0,0003	0,0000	0,0018

The result is the above table of mutual covariance of return on shares. In this case, the diagonal values are the variance of earnings per share (table 6). To calculate the total risk of the portfolio, we use the above formula (1). In this case, we calculate the sum of the share of shares and the covariance value of their return. To learn the principle of calculation, we calculate the total risk of the portfolio using Excel, setting the share of shares in the portfolio as 0.3, 0.3 and 0.4, respectively. To do this, we use the SQRT and MMULT function in the Excel formula to determine:

Total risk of the investment portfolio = SQRT (MMULT (MMULT (F30: H30; F27: H29); D27:D29))

Portfolio return is calculated as the weighted average of the return on individual shares. We calculate the investment portfolio risk using Excel with the following equation:

Total return on investment portfolio = F22 * F30 + G22 * G30 + H22 * H30

In order to form a minimum risk investment portfolio, it is necessary to determine the minimum rate of return (r_p) that can be accepted on the portfolio. So, we assume that $r_p \geq 4\%$.

Table 7.

Calculation of the total risk and return of the portfolio in Excel [6]

Share in the portfolio (w)	Company name	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank
0,3	*Tashkentvino Kombinati*	0,0050	0,0004	-0,0003
0,3	*KyzylkumTsement*	0,0004	0,0002	0,0000
0,4	*UzSanoatQurilishBank*	-0,0003	0,0000	0,0018
Transposition of a share in a portfolio (wT)		0,3	0,3	0,4
The total risk of the portfolio		2,8%		
The total profitability of the portfolio		0,43%		

In the next step, we determine the share of stocks in the portfolio (Жданов, 2021)**.** To determine the share of stocks in the portfolio, we use the "superstructure" function in Excel. To do this, follow the steps in the following sequence: Excel main menu → "Data" → "Search Resolutions" and enter the restrictive conditions for shares, provided by Markowitz investment portfolio theory, in other words the sum of shares must be equal to 1, and the shares must be positive.

Thus, in the target cell of the "Search Resolutions", select the cell that needs to be optimized (formula cell that calculates the total risk of the portfolio), enter the parameters (shares) and the specified restrictions that need to be changed. In this case, Excel changes the share of shares until it meets the established limits, forming the intended portfolio structure.

Table 8.

Calculation of minimum risk investment portfolio formation in Excel [7]

Share in the portfolio (w)	Company name	Tashkentvino Kombinati	KyzylkumTsement	UzSanoatQurilishBank
0,271	*Tashkentvino Kombinati*	0,0050	0,0004	-0,0003
0,525	*KyzylkumTsement*	0,0004	0,0002	0,0000
0,203	*UzSanoatQurilishBank*	-0,0003	0,0000	0,0018
Transposition of a share in a portfolio (wT)		0,271	0,525	0,203
The total risk of the portfolio		2,5%		
The total profitability of the portfolio		0,4%		
Limit for the sum of shares		1		

For the sum of the shares in the portfolio, we enter the constraint in cell F34 conditionally as follows: F34 = SUM (F30: H30)

As a result, the overall risk and return of the portfolio is calculated as follows:

1) the total risk of the portfolio is 2.5%;

2) total return on the portfolio 0.4%;

3) The share of shares of Tashkent winery is 27%;

4) The share of KyzylkumTsement shares is 53%;

5) The share of UzSanoatQurilishBank is20%.

This means that the portfolio can be formed from the shares of all three companies under the specified conditions, but it is more effective if the shares are formed as a result of Excel (Table 8).

Conclusion. In conclusion, the modern economy has a number of shortcomings in the investment portfolio model, including (M.B., 2016 - 40c.):

1. This model is designed for efficient capital markets. In such markets, the value of financial instruments is constantly growing and no sharp fluctuations in exchange rates are observed. The correlation between the shares is not stable and fluctuates over time, which does not reduce the level of systemic risk of the investment portfolio.

2. The future profitability of financial instruments is defined as the arithmetic mean. Such a forecast is based solely on past values, without taking into account macro- and microeconomic factors.

3. The risk of a financial instrument is measured by the variability of profitability relative to the arithmetic mean. However, a return above the arithmetic mean is not considered a risk, but rather an excess return on the action.

The above shortcomings have been addressed in many studies and models based on this model. In particular, profitability forecasting is solved in “neural networks” and multifactor models (Yu. Fama, K. French, Ross, etc.), while risk assessment is solved in ARCH, GARCH models, etc.

At the same time, the universality of the model, that is, the ability to build an investment portfolio on the model for any financial instrument and asset (shares, bonds, derivatives, indices, real estate, etc.), is positively recognized. Also, one of the main advantages of the model is that it systematizes the approach to the formation of the investment portfolio and its risk and return management. Despite the complexity of using the model, it is advisable to apply it to assets such as real estate, bonds, commodity / commodity futures, which have relatively low volatility. Markowitz’s investment portfolio theory was undoubtedly a very important innovation in the theory and practice of risk assessment, for which the author was awarded the Nobel Prize.

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